# Improved fast vector radiative transfer solution using small-angle approximation

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When the scattering phase function has a strong forward peak, the accurate solution of the vector radiative transfer equation is time-consuming. Usually, the Dirac delta function is used to replace the forward peak, such as $\delta$-M and $\delta$-Fit methods. However, the conventional ways handling the forward peak are balanced between efficiency and accuracy. Subsequently, a small-angle approximation instead of delta function is used to handle the forward scattering peak. The scattering matrix can be decomposed into the forward and the regular components and the Stokes parameters are correspondingly decomposed into the forward, regular, and error components. Therefore, the vector radiative transfer equation is decomposed into three equations: the forward, regular, and error equations. The forward equation is solved using a fast small-angle approximation and the regular equation can be quickly solved using the conventional radiative transfer methods. Using the small-angle approximation for the forward equation and the successive order of scattering method for the regular equation is verified in terms of benchmark results and the straight adding-doubling method [1]. The error equation is further considered to improve the computational efficiency.

In this presentation, I first introduce the small-angle approximation in solving the forward radiative transfer equation and then discuss how to further improve the small-angle approximation. At last the improved small-angle approximation is applied to the radiative transfer forward model and compared to conventional delta function approximation.

## Reference

[1] Sun, B., G. W. Kattawar, P. Yang, and E. Mlawer, 2017: An improved small-angle approximation for forward scattering and its use in a fast two-component radiative transfer method. *J. Atmos. Sci.* **74**, 1959–1987.

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